

NORTHEASTERN FOREST EXPERIMENT STATION

Semiannual Report  
Watershed Management Research

October 1, 1968 - March 31, 1969

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## NORTHEASTERN FOREST EXPERIMENT STATION

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NE-1601 - WATER YIELD IMPROVEMENT, Durham, New Hampshire

More on the Cleared Watershed

This summer we will be starting a new treatment phase on our Cleared Watershed 2. For the past three summers we have been using herbicides to maintain as near complete kill of all vegetation as possible. This summer we will allow natural regrowth to occur. Tentative plans are to try to keep the watershed in a high water-yielding condition, using aerial applications of herbicides about every fourth or fifth year.

As reported in previous Semianuals, the effects of forest clearing on Watershed 2 have been impressive. Statistically significant changes in streamflow occurred during 25 of the first 36 months following treatment. The 4-month period from November through February was usually the only period not showing treatment effects. When expressed as a percentage of what streamflow would have been if clearing had not been performed, the statistically significant changes range from -23 percent for April 1968 to +5350 percent for August 1968. The largest single monthly increase in streamflow was 4.64 area-inches in August 1966.

Table 1.-- Treatment effects in clearcut watershed, by low flow periods

Month	1966			1967			1968		
	Precip- itation	Stream- flow increase	% in- crease from est.	Precip- itation	Stream- flow increase	% in- crease from est.	Precip- itation	Stream- flow increase	% in- crease
	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)
July	3.86	2.88	1440	4.44	2.41	669	2.30	1.48	174
Aug	7.68	4.64	387	5.38	3.01	485	2.17	1.07	5350
Sept	4.58	2.79	288	5.32	2.49	178	2.66	1.55	2214
Oct	3.24	.78	36	4.73	.69	16	2.96	1.20	750
Total	19.36	11.09		19.87	8.60		10.09	5.30	

It is interesting to note in Table 1 that although normal or above-normal rainfall during the late summer months yielded high quantities of streamflow for the clearcut watershed, the greatest proportional streamflow increase occurred with below-normal precipitation. In spite of only slightly over 2 inches of rainfall (half the normal) in August 1968, streamflow increased by 1 area-inch. During wet summers streamflow is not nearly so critical as compared to dry summers; thus streamflow increases during the dry summers are infinitely more valuable.

#### Record Snow Water Content at Hubbard Brook

Most of New England received record snowfalls this past winter and Hubbard Brook was no exception. At this writing (March 27), the average snow-water content of the 15 snow courses at Hubbard Brook is just over 18 inches, and several north-facing courses hold nearly 21 inches. Prior to this year, the highest water content for any single snow course since start of measurement in 1955 was 12.90 inches in 1963. Most frequently our maximum water contents range from 8 to 10 inches.

Eighteen inches of water may not seem high when compared to some western snowpacks, but it must be remembered that New England snowpacks are subject to extremely rapid melt rates. This points up one of the reasons why we are concerned about this year's high water content. Usually our melt season begins around mid-March and much of the snowmelt runoff is completed by early April. This year we are well into what is normally our melt season and still have not had any appreciable snowmelt runoff. We have our fingers crossed!

#### Impressions on Oscar F

In February of 1968 we began using a Benson-Lehner, Oscar F for "point-picking" the various charts that accrue from our hydrology and meteorology studies. The Oscar F is wired through an IBM 029 keypunch and provides a punch card output. To date we have used the Oscar on 12 watershed years of hydrographs plus numerous precipitation, hygrothermograph, solar radiation, and millivolt recorder charts. In addition, other Projects have borrowed the Oscar for such uses as determining the defect dimensions on scale drawings of boards and picking points from chromatograph charts.

Generally we have been well pleased with the Oscar F performance. It is quite versatile and can be adapted to practically any type of chart. Despite its apparent sophistication, we have had very few maintenance problems and it has been surprisingly easy to train people on its operation. Point-picking with the Oscar F is quite

rapid and we have been able to reduce our data reduction time considerably. As an added benefit we have been using less computer time. We do not have to make as many reruns of our streamflow and precipitation programs since the Oscar does not make the errors that formerly accompanied manual point-picking and keypunching.

-- R. S. Pierce  
C. A. Federer  
J. W. Hornbeck

Semi-Annual Report  
October 1968 - March 1969

Project 1602 - Parsons Timber and Watershed Laboratory  
FLOODS AND WATER YIELD

Predicting Streamflow Increases:

For almost 50 years hydrologists have known that streamflow increases follow forest cutting. But even today, we hasten to apologize for inability to predict the level of this increase. I believe that the day is fast approaching when we can, indeed should, take a more positive approach to predicting streamflow response to forest cutting--at least in the hardwood covered mountains of the East.

Let's consider what we know:

1. Maximum annual increases following clearcutting range from 16 inches at Ceweeta to 14 inches at Hubbard Brook.
2. Little or no measurable increase follows removal of 20 percent or less of the stand basal area.
3. Streamflow increases seem to be linearly related to basal area removed over the range from 20 - 100 percent of the basal area.
4. Evidence is accumulating at Ceweeta and Parsons that streamflow response on a given watershed is repeatable.

There are, of course, many important forest influences that we only suspect or know imperfectly; we must not lose sight of them.

1. The confounding effects of slope and aspect on streamflow following forest cutting.
2. The effect of soil properties (depth, texture, distribution) on streamflow.
3. The effects of forest composition on streamflow.
4. The interactions of forests and climate.

Please note that these lists are not offered as definitive statements of what is known or what needs to be learned in forest hydrology. They are intended to show a picture that I think is beginning to emerge from our research. The range of possibilities for increasing streamflow by a given treatment is fairly narrow in mountains of the humid East. Increases seem to decrease from south to north as do precipitation and evaporation. Retreatment apparently repeats streamflow responses and these responses are sustainable by maintaining any given treatment. I certainly will hedge my bets carefully when making water yield predictions but I see no reason why we should not begin to make them within expected accuracy limits of  $\pm$  25 percent. Hopefully, the time is coming when subjective judgments can be replaced with prediction equations of stated accuracy but that time is still before us.

James H. Patric

Sub-surface Flow Investigations:

Our sub-surface flow study plot on Watershed 5 has been in operation for over a year. This past fall and winter we expanded our observations to include the entire slope. Not only the plot, but off-plot and down slope positions are being instrumented with gas-bubbling piezometric recorders.

Figures 1 and 2 represent a portion of the data which we collected last year. Figure 1 compares water level, as recorded in the mid-slope piezometer, and plot out-flow. Water level in the piezometer represents height of the storm-initiated temporary water table above a zero point 42 inches in the ground. Plot out-flow is measured in a .80 foot HS flume calibrated at the site. The midslope piezometer is located in the middle of the plot 55 feet up slope (22 feet elevation) from the cut off wall and approximately 120 feet below the ridge (40 feet elevation).

There appears to be a very good relation between height of the saturated zone and plot out-flow (fig. 1). The piezometric trace indicates a quicker response and faster recession in depth of saturation than does the out-flow hydrograph but this is understandable considering the different source area of each. A second piezometer located off the plot and on the same contour as the cut-off wall reacts in much the same manner as the midslope piezometer except that response is somewhat slower and peaks less sharp than for the mid-slope piezometer. The off-plot trace is more comparable to the plot hydrograph in terms of rise and recession slopes and timing of peaks. A third piezometer, located directly above the cut-off wall, compares well with the off-plot piezometer and out-flow hydrographs in many respects. The piezometric level above the cut-off wall recedes very slowly, however, and is probably held up by the soil-gravel interface. This level does drop to zero, however, at the same time that plot out-flow stops.

Figure 2 compares plot out-flow with watershed discharge for the same period as in Figure 1. The discharge from the 90 acre watershed was divided by 500 to scale the discharge down to a value comparable with plot out-flow. Here also, there is a very strong relationship between plot and watershed response.

This year we are looking more deeply into the timing of the various plot and watershed responses. In addition, we have recently installed piezometric wells and recorders on the slope below the trench and at the point where the slope is intersected by a stream channel. In this way we hope to better define the relationship between plot and watershed responses and answer the question "How does precipitation become streamflow?"

Charles A. Troendle

Access Tube Installation:

The neutron soil-moisture meter has proven to be a quick and reliable means of measuring soil moisture. Perhaps the greatest problem associated with its use is installing access tubes in rocky soils. Installing soil moisture access tubes on rocky soils indigenous to the Fernow Experimental Forest has been made easier by the recent purchase of new drilling equipment. This equipment will drill hard shale but not solid rock. Equipment found to be satisfactory on the Fernow is itemized below:

Ward's Portable Power Digger with a 7½ horsepower gasoline engine	\$355.55
Machined reducer sleeve to adapt power head to augers	10.00
2 DL 1-7/8" Kennametal Bits	7.52
1 A26LS 5 foot Kennametal Auger 1-5/8" diameter with 7/8" solid shaft	22.54
1 A26LS 8 foot Kennametal Auger 1-5/8" diameter with 7/8" solid shaft	24.30
Total Cost	\$419.91

The power digger, manufactured by General Equipment Company, was purchased from Montgomery Ward, Inc. The coal seam augers and bits were purchased from Fairmont Supply Company located in Fairmont, West Virginia. The augers must be modified by cutting off the power head adapter and drilling a 5/16 hole in the 7/8" shaft. The shaft of the auger then slips into the sleeve on the power head.

It requires at least a two-man crew to operate the power digger. The power digger and auger weigh approximately 60 pounds. Usually, a three-man crew is desirable when additional equipment such as wrenches, augers, gasoline, and access tubing must be carried for relatively long distances. Use of a three-man crew also makes it much easier to change augers. The number of access tubes installed per man day is not reduced by using a three-man crew.

We have found that the combination of the powerful engine, solid steel shafts and replaceable carbide cutting bits have been quite efficient in our channery soils. We have installed over one hundred 1-5/8 inch diameter access tubes, as many as 12 a day, ranging from 4 to 8 feet in depth using this equipment and have encountered no major problems. For the most part we have been able to drill as far into shale as we feel necessary. Our present equipment will not effectively drill hard sandstone but Kennametal does offer other bit choices which may be better suited to sandstone. The cutting edge on an auger bit was ripped off once but it still continued to function satisfactorily. The bits are relatively cheap and can be readily installed on the auger shaft. The power digger has no reverse gear. Sometimes in clay soils the auger digs too fast and literally buries itself. This necessitates backing the auger off with a pipe wrench to free it. The access tubes fit snugly into the drilled holes. We use a driving head developed by Troendle in Study No. 4300-NE-1602-13 and a leather headed mallet to drive access tubes into the drilled holes.

James N. Kochenderfer

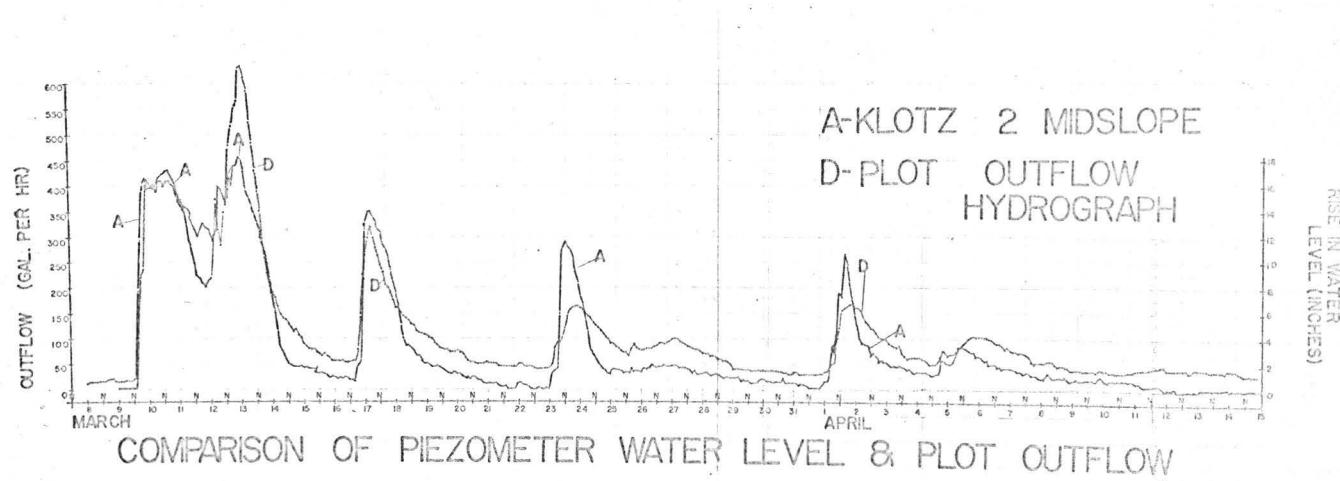


Figure 1

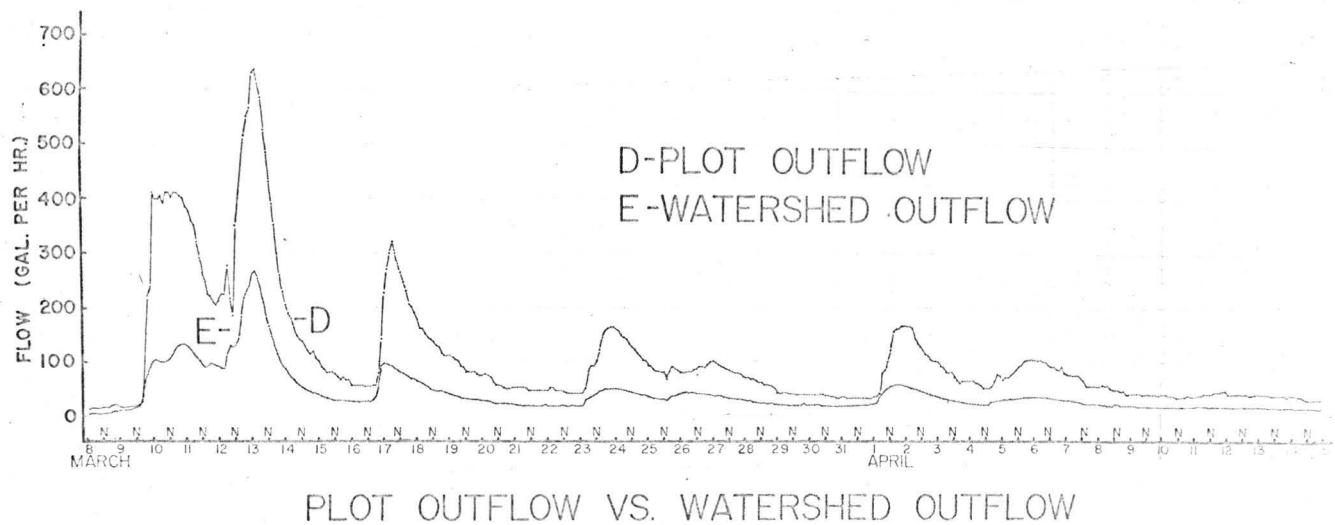


Figure 2

Upper Darby, Pennsylvania

Regional Studies

We completed a proposed Station Research Paper on Forests and floods: A reconsideration, sent it to Marvin Hoover, John Hewlett, and Art Eschner for review, and with their suggestions revised it for Washington and our office perusal. We concluded that the opportunities for attaining increased flood control benefits in the East by application of forest management practices to stands not now subject to over-grazing or frequent burning are very limited. Procedures now in use for predicting these benefits appear to be questionable in principle and erroneous in practice. The potential for obtaining flood-prevention benefits through forestry is greatest where non-forest lands, that produce substantial amounts of overland flow, can be converted to forest.

Pursuing our search for bonafide effects of land use on streamflow, with Art Eschner we completed a trend analysis of long-term streamflow records (26 to 62 years) of 25 watersheds less than 500 square miles in area. Monthly Thornthwaite balances were computed for each watershed. Double-mass curves of predicted annual water-surplus versus actual annual runoff were plotted, and their deviations plotted over time. We found numerous trends, many unexplainable. Urbanization effects showed up on two watersheds. Also, in a few instances many changes in weather stations and stream-gaging were evident. "Further study will be required."

--H. W. Lull  
K. G. Reinhart

Municipal Watersheds

At least 660 municipalities in the Northeast obtain their water supply from forested watersheds. Preliminary results from the municipal watershed survey (described in the last two Semiannual Reports) indicate that 2 million acres of forest land are associated with municipal water supply systems. Forty-six percent of this land is owned by municipalities and 11 percent by private water companies while State and Federal ownership accounts for 25 and 18 percent respectively.

Problem areas that concern watershed managers range from housing developments being established on or near their watersheds to pollution of reservoirs by seagulls. Major problems mentioned most frequently were (1) dealing with recreation pressures, (2) low flow augmentation, (3) high color of surface water from some forest areas (mostly swamps), and (4) algae growth in reservoirs.

--E. S. Corbett

NORTHEASTERN FOREST EXPERIMENT STATION

Semiannual Report  
Watershed Management Research

October 1, 1968 - March 31, 1969

NE-1604 - STREAM REGIMEN AND WATER YIELDS, SYRACUSE, N. Y.

Solar radiation relationships

In the last semiannual report some preliminary data on the albedo above a hardwood forest was given. We are investigating the spatial and temporal variation of reflected solar radiation as measured along a 100 foot tramway, 65 feet above the ground and about 5 feet above the canopy. The data have been extended to cover the full year and are presented in table 1.

Snowmelt-soil moisture investigations

Soil moisture and temperature data from the Environmental Lab at Warrensburg was related to spring runoff from a USGS Station on a nearby watershed. It is interesting to note that peak soil-moisture recharge occurred about 3 days after peak streamflow was reached.

Wind profile studies

The Three Bears wind program of Winston Covey is being adapted to handle the wind profile data at our Baldwinsville micrometeorological study area near Syracuse.

Table 1.--Albedo at solar noon above a hardwood canopy--  
cloud-free sky conditions

<u>Date</u>	<u>Incident Solar Radiation</u>	<u>Albedo</u>	<u>Remarks</u>
	<u>Ly/Min.</u>		
April 16	1.21	.12	No leaves
April 28	1.36	.12	Buds open
May 24	1.22	.12	Leaves starting
June 27	1.26	.16	Full leaf
Aug. 22	1.29	.16	Full leaf
Sept. 12	1.10	.15	Full leaf
Oct. 23	0.80	.14	No leaves
Jan. 25	0.78	.20	Snow on ground
March 5	1.08	.24	Old snow on ground
March 6	1.04	.27	New snow on ground

- R. E. Leonard

NORTHEASTERN FOREST EXPERIMENT STATION

Semiannual Report  
Watershed Management Research

October 1, 1968 - March 31, 1969  
Forest Restoration of Strip-Mined Lands, Project 1605

Grant Davis  
Project Leader

General

The Station and the School of Forest Resources, The Pennsylvania State University are conducting an "International Symposium on Ecology and Revegetation of Drastically Disturbed Sites" at the University, August 3 to 16, 1969. Funds were obtained from NATO and Title I of the Higher Education Act. Other cooperating agencies are IUFRO, Section 21; Pa. Dept. of Mines and Minerals, National Coal Assn., and Bituminous Coal Research, Inc. The program has been prepared, speakers selected, and brochures were circulated at the end of March. Grant Davis and Dr. Russell J. Hutnik have been laying most of the groundwork.

Research Initiated in West Virginia

In cooperation with the West Virginia Surface Mine Association and the West Virginia Department of Natural Resources the Station has expanded our NE-1605 project to West Virginia. Bill Plass was transferred to Princeton to conduct the program, and Randolph Gordon will be his Research Technician. A Steering Committee made up of individuals representing agencies interested in surface mine research was formed to help formulate a formal program. After several meetings of the Steering Committee, the following studies were selected to be initiated in 1969:

Hydrology: I- Determine the effect of strip mining on watershed values.  
II- The effect of a surface application of fly ash on the surface moisture of a spoil.

Geology: I- The correlation of chemical properties of the mined coal seam with the chemical properties of the spoil.  
II- The identification of acid producing strata in the overburden of the Upper Freeport coal seam in Preston County.  
III- The correlation of the chemical composition of rock strata in the overburden with the chemistry of the sediment and surface runoff from spoil banks.

Revegetation: I- Fertility evaluations of West Virginia spoils.  
II- Rates of nitrogen and phosphorus for establishing quick herbaceous cover.

- III- An evaluation of plant materials supplied by the Plant Materials Centers of the Soil Conservation Service.
- IV- A field evaluation of pelleted black locust seed.
- V- An evaluation of a pitch x loblolly hybrid.

### Hydrology

Measurements of density of leveled spoil banks in area-type strip-mining indicate a significant difference between "ridges" and "valleys". These ridges and valleys represent topography of the spoil prior to grading. Ridge lines were found to be more dense than valley locations to a depth of nine feet. From nine to fifteen feet there was no difference. From our preliminary measurements it appears that ridges become somewhat compacted by the spoil stacking process and that when these ridgetops are pushed off the "fill" is not so compacted. The dozer probably compacts the ridges still further during the grading process.

There appears to be no significant difference in percent by volume of subsurface moisture on ridges and valleys. However, since there is quite a difference in density there is a subsequent difference in percent moisture by weight. In this respect valleys would have more moisture. We must now determine the moisture coefficients in order to study the situation of available moisture.

Willie R. Curtis

### Revegetation

Tree Growth on Spoils-- Fifth year survival and height growth of trees planted on Pennsylvania anthracite spoils were summarized and submitted for publication. Eleven coniferous and three hardwood species were planted on both graded and ungraded spoils. In general, hardwoods survived somewhat better than the conifers and height growth was much better. Trees planted on graded sites survived better than on ungraded sites where erosion and rock sliding were the primary cause of mortality.

Hydroseeding--In the spring of 1967 two seed mixtures, each containing a softwood, hardwood, grass and a legume species, were hydroseeded on 32 plots on deep-and strip-mine spoils. The seeding rate was predetermined together with lime, fertilizer and silva-fibre mulch which were used as treatments. The table below shows the number of seedlings (per acre) growing after the second growing season. Notice that there was a general increase in trees and a decrease in grasses compared to the first growing season reported a year ago.

Number of tree, grass and legume seedlings growing on anthracite  
coal spoils

Species	Graded coal breaker refuse (Carbonaceous shale)	Graded strip-mine spoil (Gray shale)
<u>Mixture A</u>		
Red pine	0	1,664
Gray birch	908	7,109
Rye grass	302	38,115
Lespedeza	114,496	179,685
<u>Mixture B</u>		
Scotch pine	151	1,210
Black locust	0	0
Tall fescue	7,714	178,324
Crownvetch	21,478	7,865

M. Czapowskyj

Tubelings--An interim report on the tubeling study was prepared and distributed to the Pennsylvania Research Committee. Scotch pine and red pine tubelings were set out on four planting sites in the bituminous region of Pennsylvania. Planting dates were April 15, May 13, June 10, and July 8, 1968. Fall survival was good for both species for the first three dates (about 86%), but dropped off somewhat on the July 8 date (about 57%). A visit to the planting sites this spring revealed that many of the tubelings had been frost-heaved over the winter. Extent of damage will be noted in the next report.

Deep-Mine Spoils--Two new studies have been started during the report period. These are: (1) A Survey of Deep-Mine Spoils in the Bituminous Region of Pennsylvania and (2) Physical and chemical characteristics of Deep-Mine Spoils of the Bituminous Region of Pennsylvania. As of March 15, 11 of the 24 Bituminous Deep-Mine Districts have been surveyed and samples have been collected from representative deep-mine spoil piles in each district. A total of 154 samples have been collected from 43 different piles. The samples are being seived to determine rock and soil fractions. To date, 90 samples have been seived. It is estimated that about 160 more spoil samples (representing 40 piles) will be collected and seived to complete these phases of the studies.

Walter H. Davidson

SEMIANNUAL REPORT  
WATERSHED MANAGEMENT RESEARCH DIVISION  
Project NE-1606, Columbus, Ohio

October 1, 1968-March 31, 1969

NE-1606 - MANAGEMENT OF STORM RUNOFF, COLUMBUS, OHIO

Hydraulic Conductivity Studies

In the seemingly never-ending search for a reliable field technique for measuring saturated hydraulic conductivity of layered forest soils, we have dusted off a plot technique we first roughed out in 1962 but shelved in favor of existing agricultural drainage tools. None of the latter have proven worthwhile so we've gone back to our plot technique.

We first conceived this idea while working on groundwater problems dealing with radial flow to a well. We were assuming our well was in the center of a circular island with steady discharge to the well from a constant source of water surrounding the island. And this is essentially what the technique involves.

We excavate a circular plot, about 14-feet in diameter, down to impermeable strata. To protect the freshly exposed face from wetting and drying and eventual sloughing, the block is wrapped with several layers of heavy burlap. This in turn is secured by a tight wrap of one-inch chicken wire.

The water reservoir can be (a) a steel tank surrounding the soil block, (b) sheets of plastic secured to the outer walls of the excavation, or better yet, (c) mats of fiberglass or burlap plastered to the outer wall with an asphalt emulsion. Water levels in the outer tank are controlled by one or several cattle tank float valves fed by calibrated drums. Our drums are equipped with manometers in order that we can measure input rates and quantities to the reservoir during a run. The drums, in turn, are supplied by large cattle tanks. Water supply is important and can be a determining factor in the plot location--it may require 3,000 to 4,000 gallons of water to completely saturate a 14 foot plot, 4 feet deep.

An auger hole well is carefully drilled in the center of the plot, several small diameter observation holes bored between the well and the water tank, and a datum for measuring water levels established. We had hoped to use a constant pumping rate technique, but the soil depths are too shallow for existing pumps to maintain steady discharge. Instead we have used the standardized auger-hole technique; this gave reproducible results in 12 runs in each of the three plots we worked with. We hope this year to test the auger-hole technique with one or several other field methods on each plot.

The advantages of this plot are (a) relatively cheap to install, (b) extremely large compared to core methods, (c) water table levels can be maintained at any horizon and well drawdown to calculate permeability of this horizon, and (d) actually simulate field conditions if water level in the outer tank is maintained at a constant level.

Disadvantages are (a) difficult to use on slopes where horizons are parallel to the slope, and (b) system somewhat dependent on the use of existing auger hole technique and Darcy's law.

We were caught by freezing weather which shortened our period of observation, but hope to develop both a better measurement technique and a system that will handle adverse slope conditions.

#### Effect of Woody Plant Roots on Forest Soil Physical Properties

Dr. G. M. Aubertin is compiling some 5,000 titles of articles dealing with roots and is attempting to cross reference these by subject matter and content. This is a difficult task in that many of the articles cover overlapping subjects. We cannot, however, reproduce complete listings of these titles. Should anyone in our reading audience desire a reasonably complete listing of root titles we suggest that they visit our lab and talk with Dr. Aubertin.

#### Meetings and Talks

October 1968-- Ron Whipkey addressed the U.S.D.A. Club of Franklin County, Ohio, and told of his 1967 trip to Russia.

November 1968-- Dr. Aubertin attended the national meeting of the American Society of Agronomy at New Orleans.

February 1969-- Ron Whipkey gave a paper on hydraulic conductivity of layered forest soils at the A.S.C.E., Engineering Water Resources Conference in New Orleans.

-- R. Z. Whipkey

-- G. M. Aubertin

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